

3/PRTS

## APPARATUS FOR RECORDING A THERMOOPTICAL IMAGE OF THE FEMALE BREAST

The present invention relates to an apparatus for recording a thermooptical image of the female breast.

For the diagnosis of mammary carcinomas and early detection within the framework of preventative medical examinations, most frequently mammography, i.e. an x-ray method is used. This method leads to a very limited radiation exposure for the patient. As a supplement to mammography thermography is available in which with the aid of the skin temperature mammary carcinomas can be diagnosed on the breast.

The prior art has proposed that most varied methods for this purpose. In one group of methods the skin temperatures are directly measured on the breast and are optionally electronically further processed. Thus, e.g. WO 79/00594 and U.S. Patent 3,970,074 disclose apparatuses in which the breast is pressed against a plate equipped in matrix-like manner with temperature sensors and measurement of the skin temperature takes place. The measured data are electronically processed and specific temperature distributions on the skin are an indication of a mammary carcinoma.

U.S. Patent 4,055,166 discloses a brassier, which is fitted with individual temperature sensors. Thus, the skin temperature is constantly checked at the corresponding points. Specific changes to the skin temperature indicate the existence of mammary carcinomas.

A second group of thermography methods is constituted by so-called plate thermography and a corresponding apparatus is disclosed by D.E. 83 26 341 U1. A thermographic plate is pressed onto the female breast. As a function of the temperature, a thermographic coating of the plate assumes

different colors. This renders optically visible in thermographic manner the pattern of vessels, which are warmer than other areas. Specific structures or features indicate abnormal changes. The actual diagnostic method of plate thermography is described in greater detail in "Atlas der Plattenthermographie" by G. Lauth and G. Mühlberger. This atlas gives an introduction to doctors  
5 inexperienced in plate thermography. The performance of plate thermography requires very considerable diagnostic experience on the part of the treating doctor and is subject to a high error rate, particularly in the case of inexperienced doctors.

On the basis of this, the problem of the invention is to provide an apparatus facilitating diagnosis of pathological changes.

10 According to the invention this problem is solved by an apparatus for recording a thermo optical image of the female breast with a casing which is opaque except on the side facing the breast, where it carries a frame, a thermo optical foil, which can be fixed to the frame, a transparent cooling box arranged on the frame side remote from the breast and having on its side remote from the breast an antireflection disk, which has a cooling medium inlet and a cooling medium outlet and in its initial  
15 position is not in contact with the foil, a thermostat adjustable with respect to the temperature of a cooling medium and which for the formation of a cooling circuit is connected by means of hose lines to the cooling medium inlet and outlet, an illuminating system located in the casing for illuminating the thermooptical foil, a digital camera positioned facing the frame in the casing, a clamping device for clamping the breast between two surfaces, one of said two surfaces being formed by the foil, a  
20 contact producing device for producing a surface contact between a cooling box side facing the foil and the foil side remote from the breast, a timing system for measuring the time duration as from

producing contact, and a release mechanism connected to the timing system for the automatic release of the digital camera at the end of a presettable time duration.

According to a special embodiment of the invention, the clamping device comprises a pad extending parallel to the frame and connected to the casing and whose spacing from the frame can be modified.

In particular, the pad can be connected to the casing by means of a mounting support located at right angles thereto.

According to another special embodiment of the invention, the frame is quadrangular and at its four corners is held on the casing by means of pins, springs extending concentrically to the pins in such a way that a foil fixed to the frame is at a distance from the cooling box when the springs are in the unloaded state.

A locking device for locking the frame on producing contact between the foil and the cooling box after compressing the springs can be provided.

There can also be a multi-articulation arm, to whose one end is fitted the casing.

Another special embodiment of the invention is characterized by an instrument trolley connected to the other end of the arm and which permits an easy transportation of the apparatus and also an easy handling of the casing in situ.

Advantageously another embodiment of the invention with a screen connected to the digital camera is provided and as a result images can be observed on the screen.

Advantageously there is a computer with a keyboard.

It is in particular possible for the computer to contain the timing system and the release mechanism.

A further special embodiment of the invention is characterized by a storage means for storing the digital images recorded by means of the digital camera.

Another special embodiment of the invention is characterized by an output device for outputting the digital images on a printer or a storage medium. The storage medium can e.g. be a CD-ROM or a diskette.

Another special embodiment of the invention is characterized by an image evaluating device connected to the digital camera for the automatic evaluation of the information contained in the recorded image in connection with the existence of a pathological change.

Advantageously the image evaluating device has a means for comparing the present image with earlier images of the same breast or with reference images.

The image evaluating device can also have a means for examining an image for structures or features characteristic of a mammary carcinoma.

Finally, another embodiment of the invention is characterized in that the screen is subdivided into two parts, one window being used for displaying the present image and the other window for displaying an earlier image of the same breast or a reference image.

The invention is based on the surprising finding that through the cooling box combined with the cooling circuit, the illuminating system and the clamping device it is possible to standardize thermooptical images. This means that for the same patient the same recording conditions can always be reproduced, so that the treating doctor can easily detect pathological changes, i.e. can more easily make a more reliable diagnosis. In addition, standardized, thermooptical images permit an automatic diagnosis.

Further features and advantages of the invention can be gathered from the claims and the following description of an embodiment with reference to the attached drawings, wherein show:

FIG. 1 is a diagrammatic side view of part of a special embodiment of an apparatus for recording a thermooptical image of the female breast.

FIG. 2 is another part of the apparatus of FIG. 1.

FIG. 3 is diagrammatically the complete apparatus of FIG. 1 when used on a patient.

FIG. 1 diagrammatically shows part of a special embodiment of the apparatus according to the invention in side view. The apparatus comprises a casing 4 which, for standardizing the thermooptical images, is opaque except on the side facing the breast where it has a frames 9. This is a prerequisite for recording free from external reflections. The frame 9 receives a thermooptical foil or film 1. On the side of the frame 9 directed towards the casing interior is provided a transparent cooling box or cooler 7 with an antireflection disk 6 placed on its side directed towards the casing interior. The antireflection disk 6 simultaneously forms the rear wall of the cooling box 7. The foil 1 stretched over the narrow frame 9 is at a distance of 2 to 3 centimeters in front of the front wall 8 of the cooling box 7. The quadrangular frame 9 is held in the four corners of the casing 4 by steel pins 10 and the spacing of the foil 1 from the front wall of the cooling box 7 is ensured by four springs 11. The springs 11 are inverted over the pins 10 and in the relaxed state are sufficiently long to hold the foil 1 at the said spacing from the front wall 8 of the cooling box 7. After placing the foil 1 on the breast to be examined, it is possible to correct the position of said foil 1 without any surface contact having taken place between the foil 1 and the front wall 8 of the cooling box 7.

The cooling box 7 has a cooling medium inlet 12a and a cooling medium outlet 12b connecting it in a circuit with a thermostat 17 by means of hose lines 12c (cf. fig. 2). Water is the cooling medium. A continuous water circulation and a constant water temperature ensure the constancy of the temperature of the foil 1. Based on the thermal sensitivity of the foil 1, the set cooling should always be constant. It is possible to manually adjust the degree of cooling by means of a keyboard 13 (cf. fig. 2) of a computer 3 (cf. fig. 2).

The casing 4 also contains a digital camera 2 facing the frame 9. An illuminating system in the form of two lamps 5 is used for illuminating the foil 1 and is oriented in such a way that recordings using the digital camera are optimized. The lamps 5 also contribute to standardization.

For the gentle clamping of the breast between the foil 1 and the pad 14, the latter can be moved backwards and forwards in the horizontal plane by means of a mounting support 15 in FIG. 1 and this also contributes to standardization.

FIG. 2 diagrammatically shows another part of the apparatus of FIG. 1. A thermostat 17, a computer 3 with a keyboard 13 and a screen 16 are located in an instrument trolley 19, to which is fixed a not shown, but visible in FIG. 3 multi-articulation arm 18, to whose other end is fixed the casing 4. The arm permits mobility and can be locked. In its interior are located the not shown supply lines for the digital camera 2, the cooling of the cooling box 7 and the illuminating systems 5. The use of the system will now be described relative to FIG. 3, in which the foil 1 is rotated forwards by approximately 90° for representation purposes.

By placing a thermoplastic foil 1 on the female breast a heat pattern in different colors corresponding to the areal thermal states of the skin appears on the foil. This thermal pattern is reversible after the foil has been removed from the breast. Coloring on the foil 1 can be minimized

by supplying cold. The color patterns are more sharply contoured and more contrasty to the black environment. Through the supply of cold the main aim is to "cool away" the skin heat and the peaks of heat dissipated from more low-lying heat sources are displayed.

Recording positions correspond to those for mammography, but with the difference that in the case of mammae of the of the normal size, two lateral and two craniocaudal exposures are made for each breast. This is due to the fact that in "vascugraphy" the emitted heat is measured and a greater sensitivity can be obtained by measuring from both sides. After placing the foil 1 on the breast, the latter is held with the soft pad 14, which can be brought into position by the patient. This has the advantage of avoiding the unpleasant association with the "squeezing examination" of mammography. As in the case of a constant temperature of the cooling medium and constant heat sensitivity of the foil during the examination the duration of cooling is not without significance and at the same time standardization is required, it is necessary to define the starting and ending time of the cooling process. This is brought about in that at the instant when the foil 1 is gently pressed counter to the tension of springs 10 on a cooling box 7 and a not shown locking means snaps in, a not shown timing system starts to measure the cooling time period and at the end of a presettable period automatic release of the digital camera 2 takes place by means of a not shown release mechanism. After each shot or recording, the pad 14 is brought into its starting or initial position by means of a mounting support 15 with not shown gas spring pressure. Through standardizing these settings a maximum reproducibility is achieved. During recording or shooting, all the settings can be monitored on the screen 16. The dimensions of the foil correspond to those of a mammographic film with the size 18 x 24 centimeters. On replacing the foil by a finished mammography image (e.g. a positive case) and homogeneous transillumination of the film from the outside in the direction of the

digital camera 2, it is possible to obtain a simple, inexpensive form of digitized storage of the mammogram of the particular patient. The congruent superimposing of the thermal image and the mammogram on the screen can provide valuable information to the diagnosing doctor.

The thermooptical image recorded by the digital camera 2 is transferred to the computer 3, where an image evaluating means carries out an automatic evaluation of the image by means of a special software.

By means of the apparatus described hereinbefore the interpretation of thermooptical images is no longer left to the examining doctor and is instead carried out by an image evaluating means. As a result of the thermographically obtained vascular pattern and the shape of the patient's vessels with the aid of reference data, said means detects pathological changes. This is particularly appropriate during the initial examinations of a patient. However, if previous recordings or exposures exist, it is possible to carry out a comparison of the present recording with the previous one. This procedure is based on the finding that the vascular pattern in the female breast, in the same way as a fingerprint, is individual to every woman and remains unchanged. If changes occur in the vascular pattern and therefore in the thermooptical image, this indicates a pathological change, which can then be further investigated, e.g. by a biopsy.

The features of the invention disclosed in the preceding description, the drawings and the claims can be essential to the implementation of the different embodiments of the invention, both individually and in random combination.